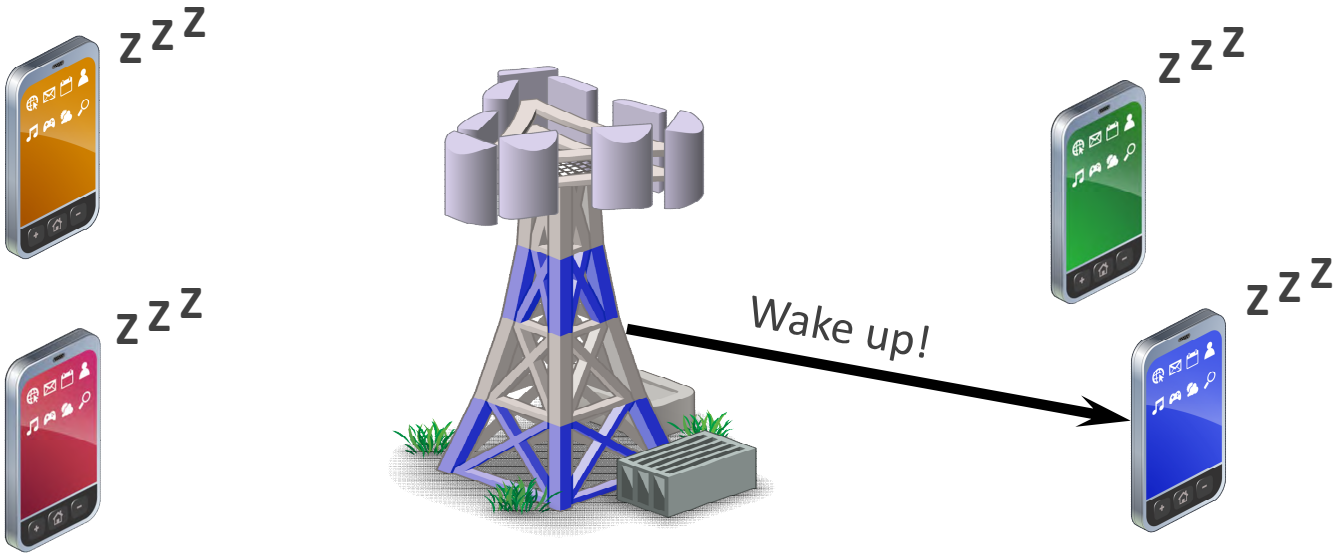

INTELLECTUAL VENTURES®
v. Sprint Spectrum, L.P., et al.; Lead Case No. 2:17-cv-00662-JRG
Plaintiff's Technical Tutorial

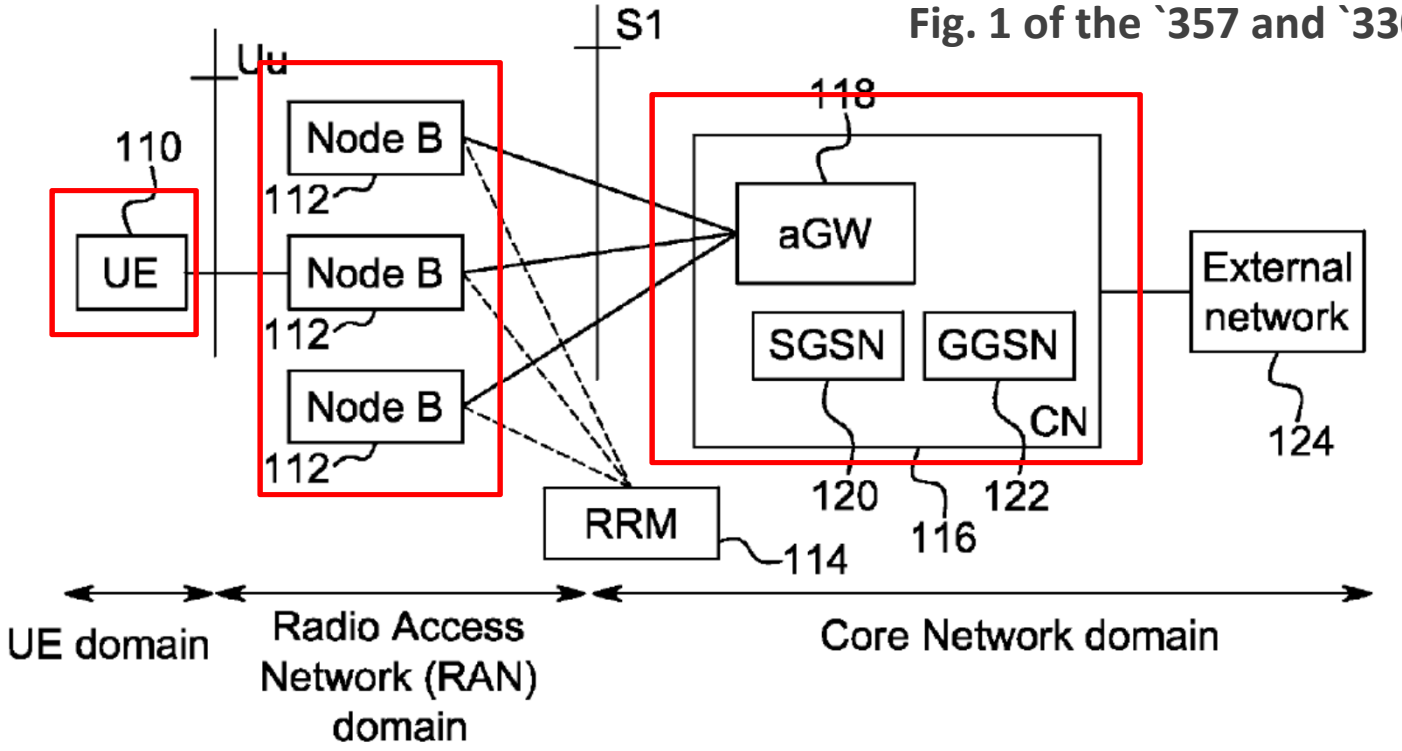
U.S. Patent Nos. 8,682,357 and 9,532,330

`357 and `330 Patents: Paging in Wireless Networks



- Inactive phones minimize battery power consumption by entering into a sleep mode, where they have limited connectivity with the base station. `357 patent, 1:10-16.
- When the network has data to send, it notifies the phone through a paging process.

`357 and `330 Patents: Paging in Wireless Networks



- Paging is initiated at the core network, which sends a paging message to one or more base stations.
- If the phone that is to be paged is in communication with the base station, the base station initiates a paging process.

`357 and `330 Patents: Two-Stage Paging Process

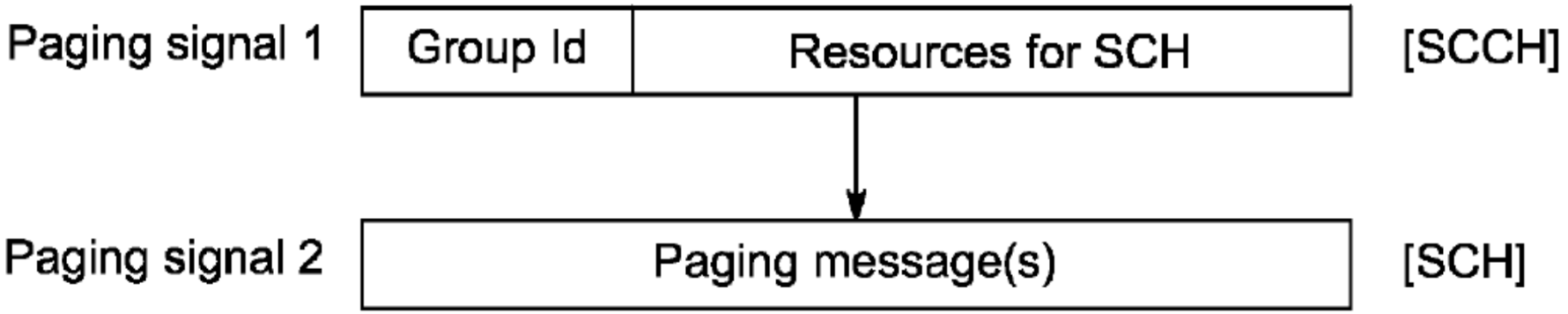


Fig. 9 of the `357 and `330 Patents

Implementations of the invention involve a two-stage paging process. *See, e.g.,* `357 Patent, 5:66-6:3.

`357 and `330 Patents: Two-Stage Paging Process

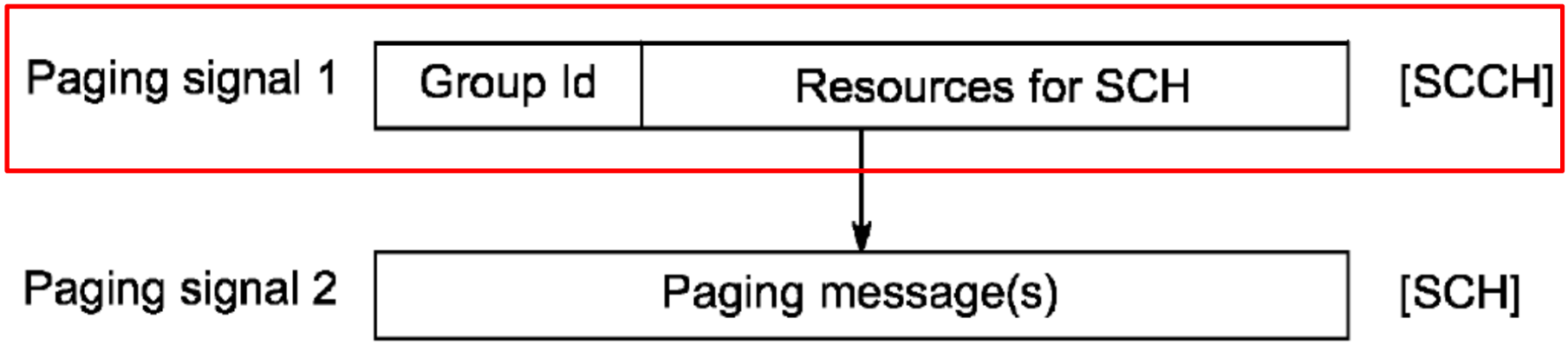


Fig. 9 of the `357 and `330 Patents

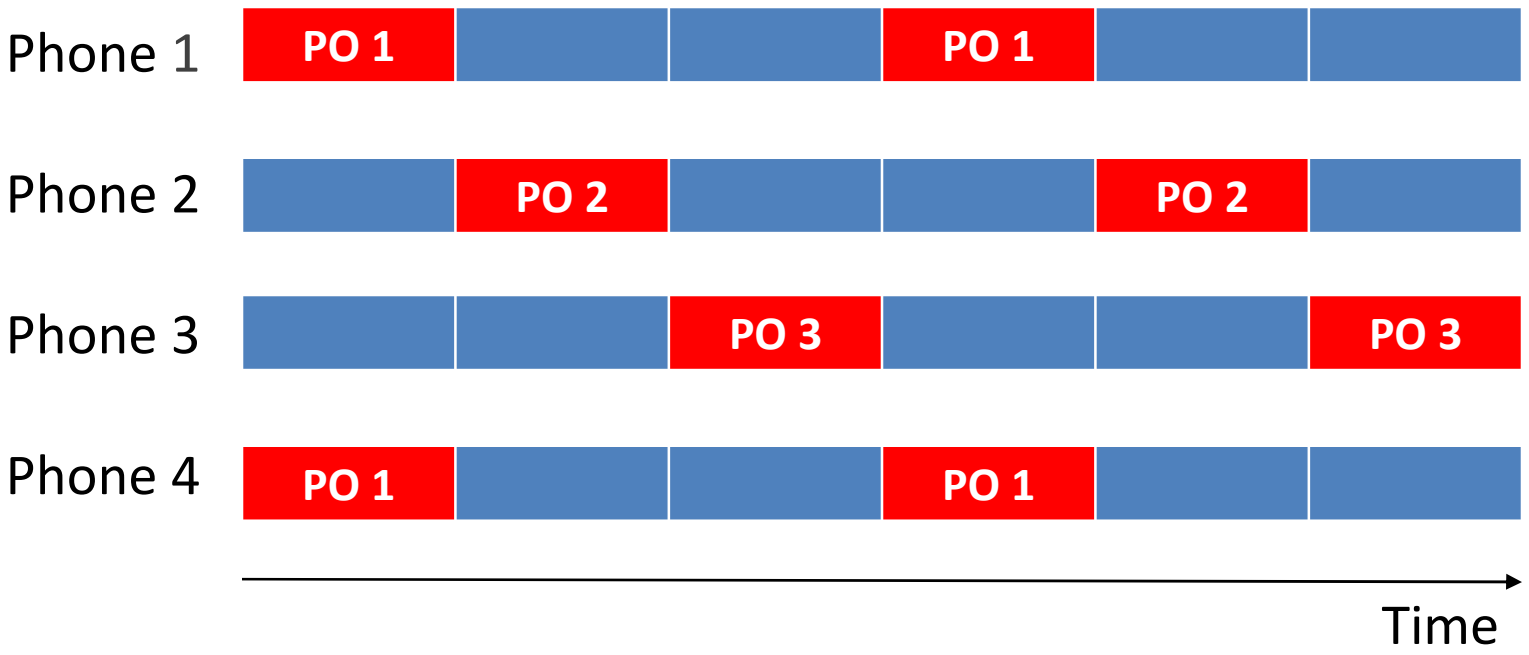
- In one embodiment of two-stage paging, the base station sends paging signal 1 on a control channel to a group of phones.
- To conserve battery, phones listen for this signal only at particular time slots (or paging occasions) using discontinuous reception ("DRX").

`357 and `330 Patents: Discontinuous Reception

- Discontinuous Reception ("DRX") allows a phone to periodically awaken to monitor for a signal from a base station.
- In DRX, a phone in sleep mode performs little or no radio activity, and does not transmit or receive data.
- If the phone does not detect a signal from the base station when it awakens, it will go back to sleep.

'357 Patent at 2:5-20

`357 and `330 Patents: DRX and Paging Occasions



- Each phone is assigned a particular time slot (or paging occasion) at which to awaken. More than one phone may be assigned a given paging occasion (*e.g.*, Phone 1 and Phone 4 above).
- The network knows when the phone to be paged will be monitoring and sends paging signal 1 at that time.

'357 Patent at 6:56-59.

`357 and `330 Patents: Two-Stage Paging Process

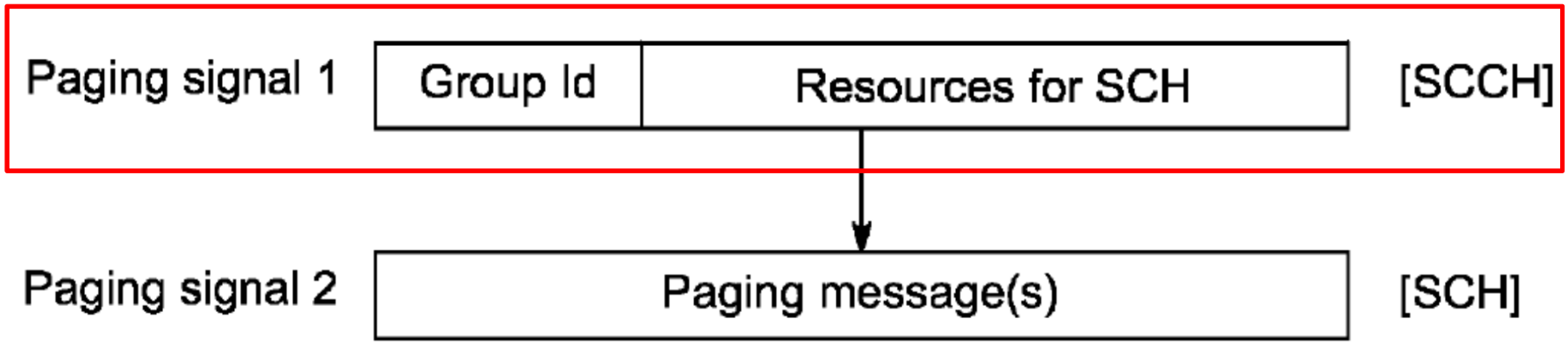


Fig. 9 of the `357 and `330 Patents

- The base station sends paging signal 1 on a control channel at a paging occasion associated with a group of phones, including the phone that needs to be paged. If a phone belongs to the group, it detects and decodes the signal.
- In some examples, the base station alternatively sends "an ID specified for paging (paging ID)."

'357 Patent at 6:21-22, 50-65.

`357 and `330 Patents: Flexible Resources

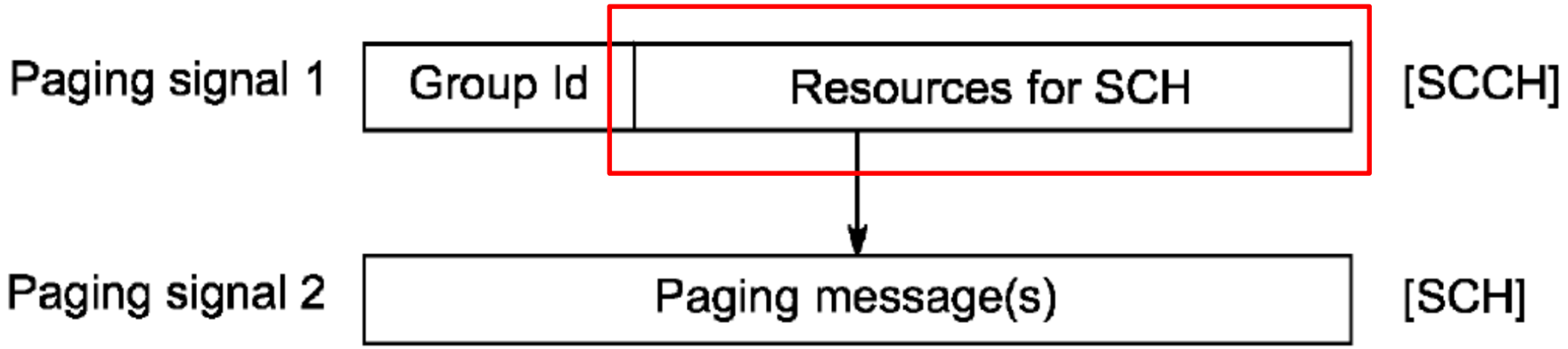


Fig. 9 of the `357 and `330 Patents

- The base station includes "resources allocated for a corresponding [shared] channel, which carries [paging signal 2]." `357 Patent, 6:60-63.
- The `357 and `330 Patents allow the base station to select the resources, thus providing for flexibility and reliability over prior art systems which used a "fixed time offset." *Id.* at 2:2-4.

`357 and `330 Patents: Two-Step Paging Process

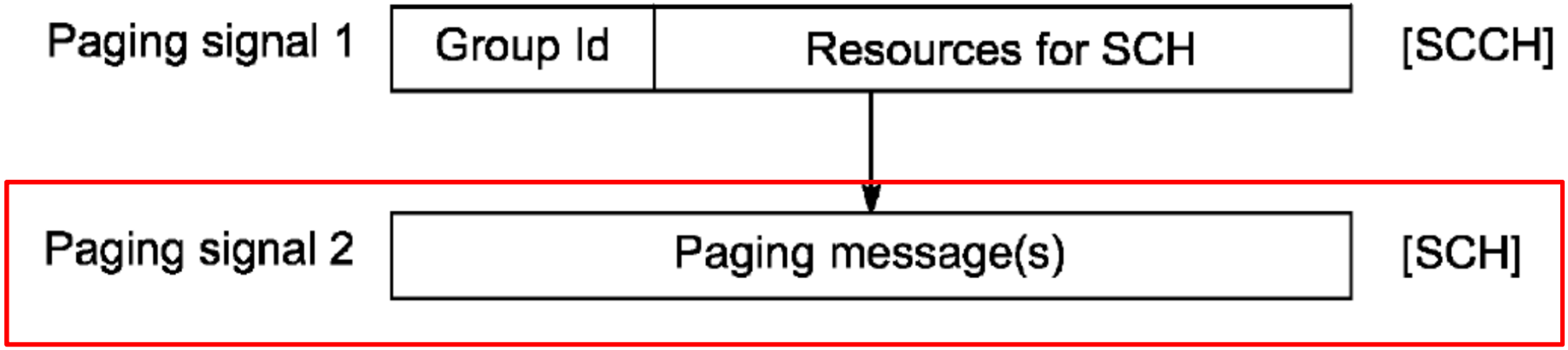


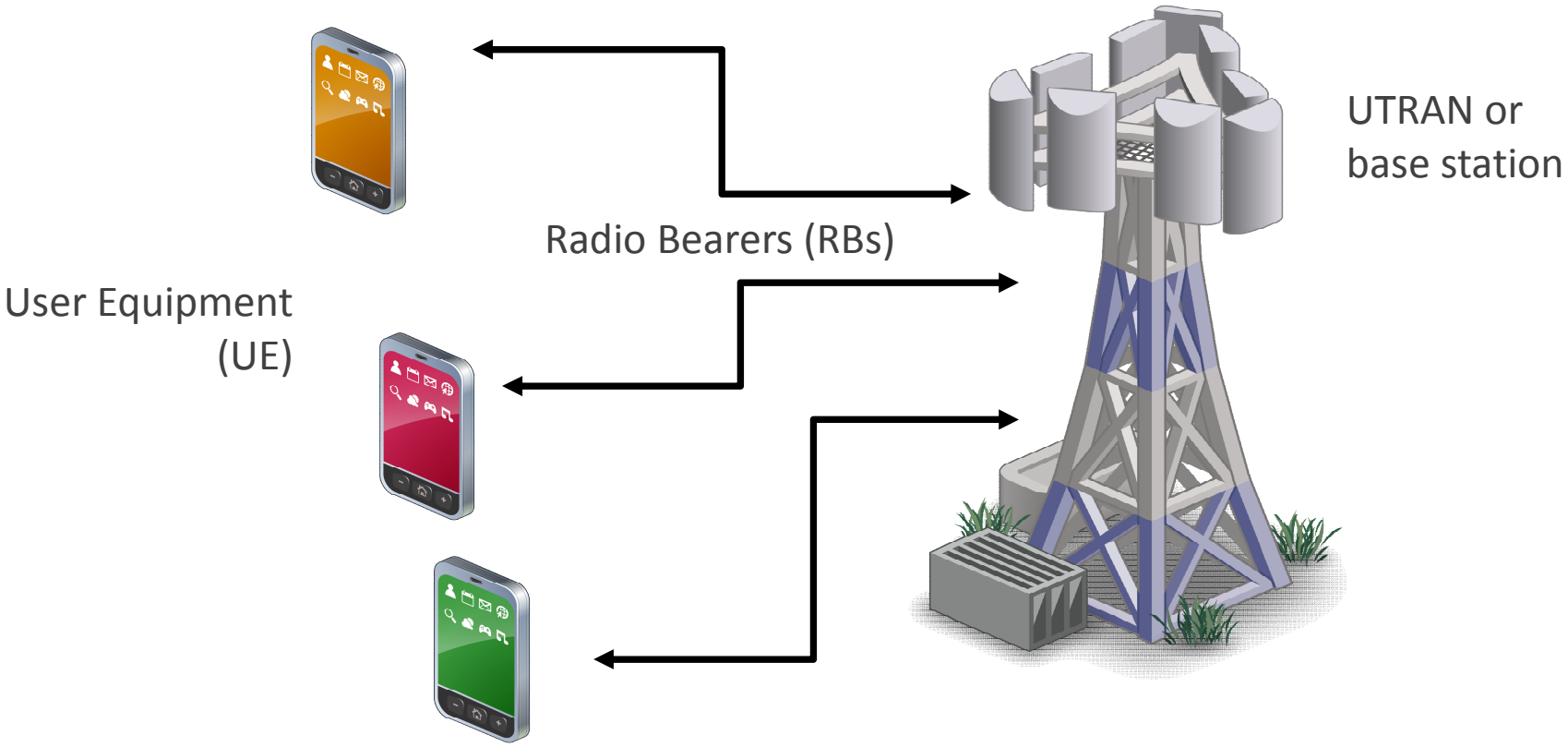
Fig. 9 of the `357 and `330 Patents

- If the phone belongs to the group of phones which received the first signal, it will read the allocated resources on the shared channel for paging signal 2.
- If paging signal 2 includes an identifier of the phone (*e.g.*, IMSI), it knows to awaken from sleep mode.

'357 Patent at 6:44-46, 63-65.

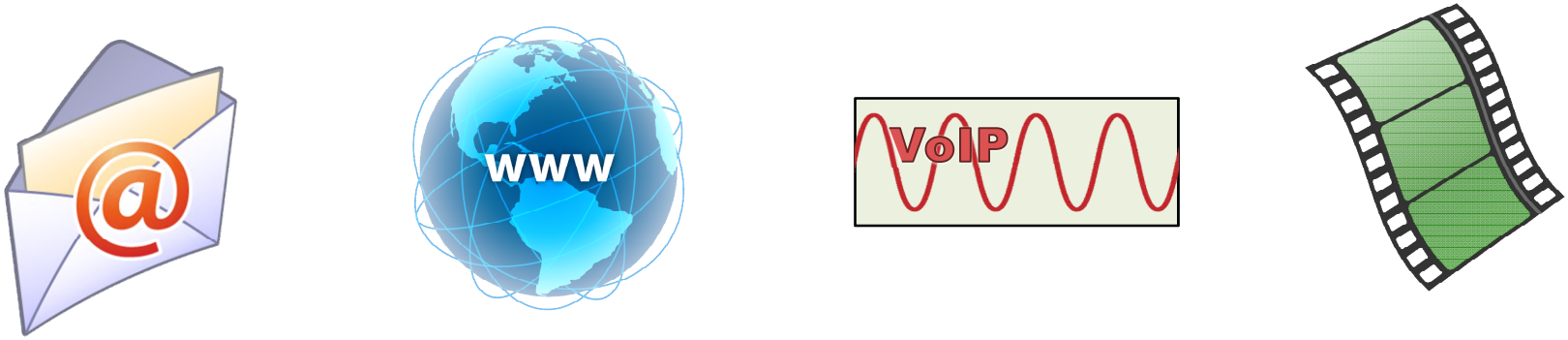
U.S. Patent Nos. 9,320,018 and 9,681,466

Communications Between UTRAN and UE



- Signals from the UTRAN to the UE are in the “Downlink” direction.
- Signals from the UE to the UTRAN are in the “Uplink” direction.

Quality of Service ("QoS")



- Different logical channels have different Quality-of-Service ("QoS") requirements.
- The '018 and '466 patents aim to achieve "quality of service (QoS) differentiation between different services carried over IP over the wireless network…" '018 patent at 5:58-60

'018 and '466 Patents: Uplink Scheduling

The base station sends
S_{tier} weighting parameters to the UE

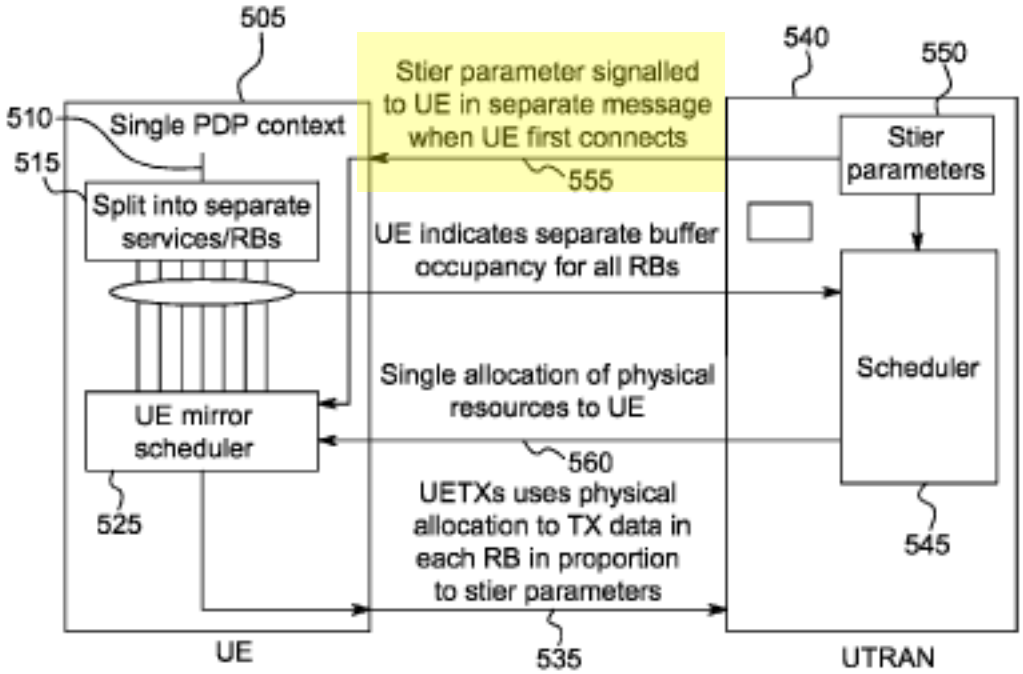


FIG. 5

'018 patent, 9:46-49

'018 and '466 Patents: Uplink Scheduling

The UE sends the base station Buffer Status Reports (BSRs) of how much data is queued for uplink on different radio bearers.

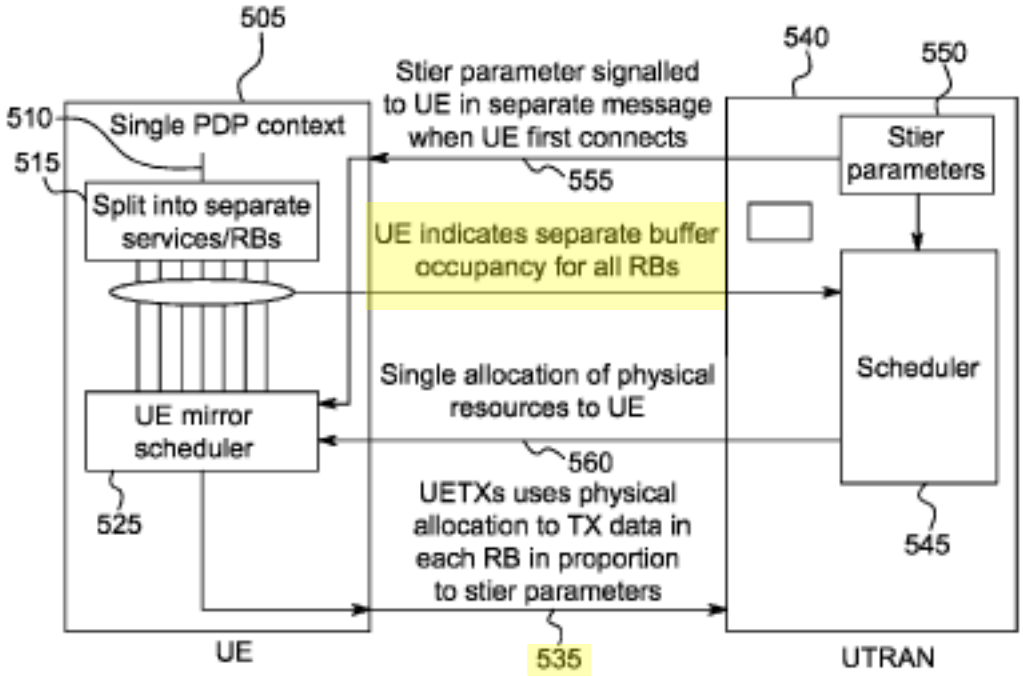


FIG. 5

'018 patent, 9:60-62

'018 and '466 Patents: Uplink Scheduling

The base station allocates uplink resources (e.g. bandwidth) for the UE.

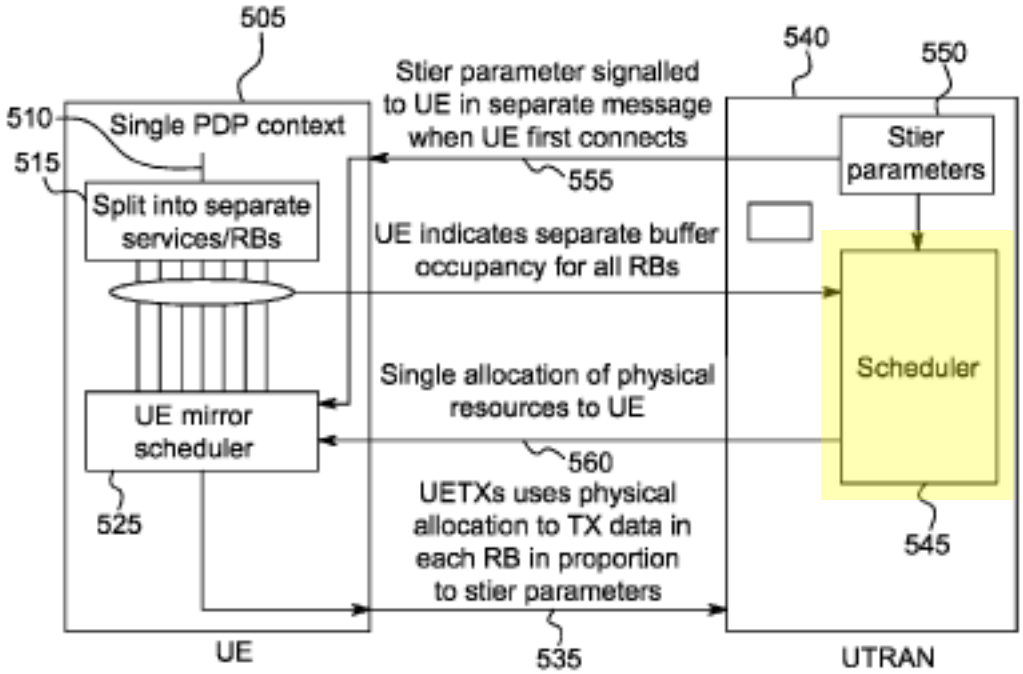


FIG. 5

'018 patent, 9:60-62; 10:2-4

'018 and '466 Patents: Uplink Scheduling

The base station informs the UE what the UE's total uplink allocation is.

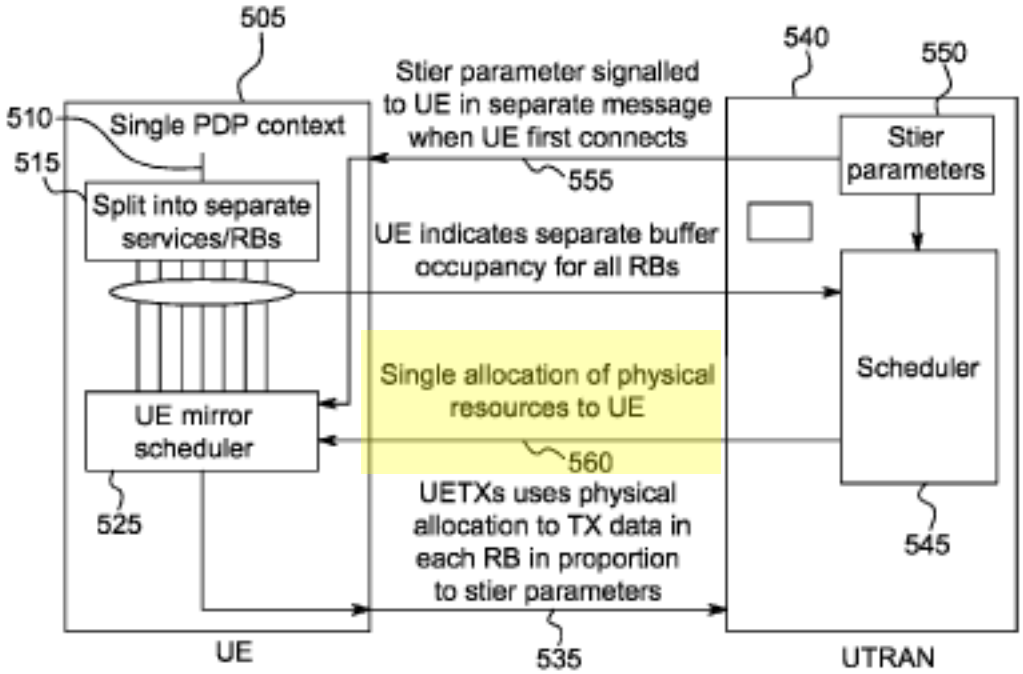


FIG. 5

'018 patent, 10:2-4

'018 and '466 Patents: Uplink Scheduling

The UE divides its total uplink allocation among radio bearers using the weighting parameters.

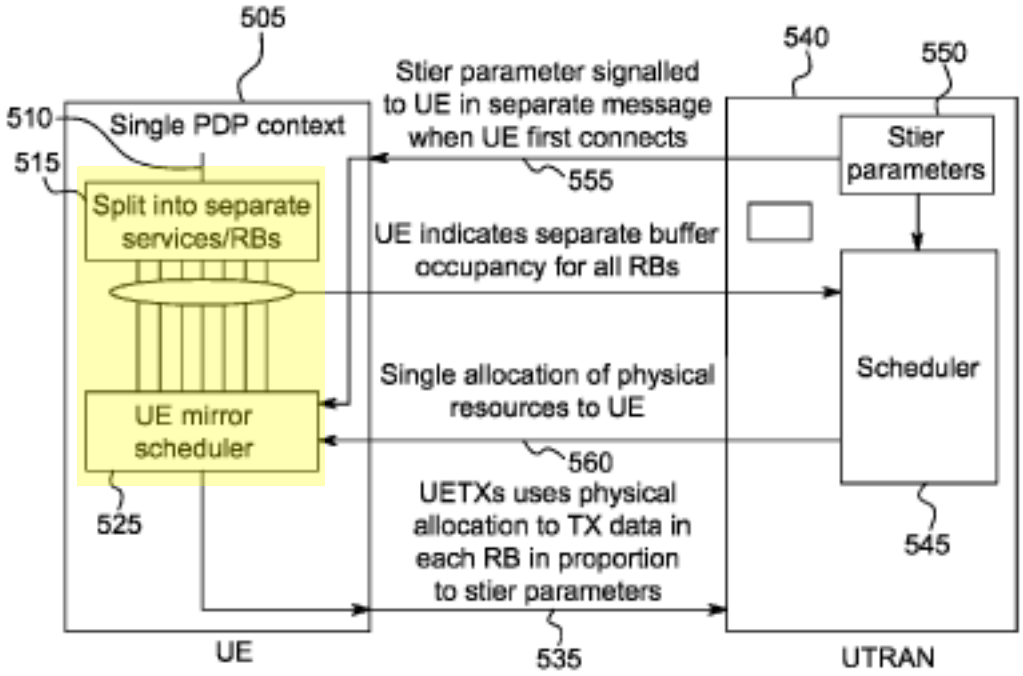


FIG. 5

'018 patent, 9:38-42

'018 and '466 Patents: Uplink Scheduling

The UE transmits radio bearer data to the base station according to how the allocation has been divided.

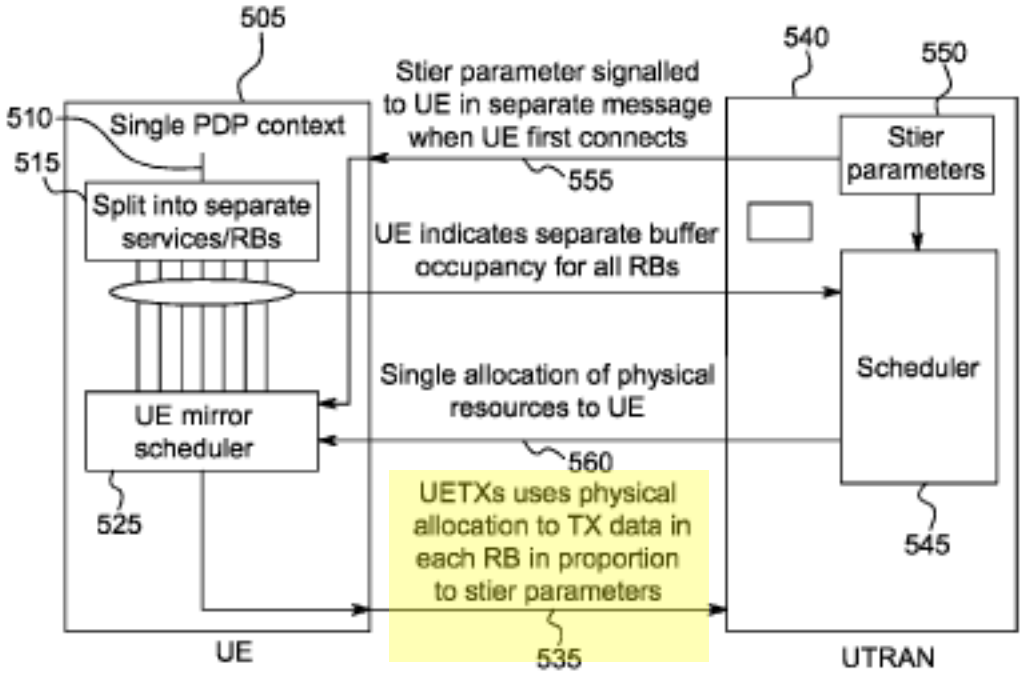


FIG. 5

'018 patent, 9:38-42

’018 and ‘466 Patents: Uplink Scheduling

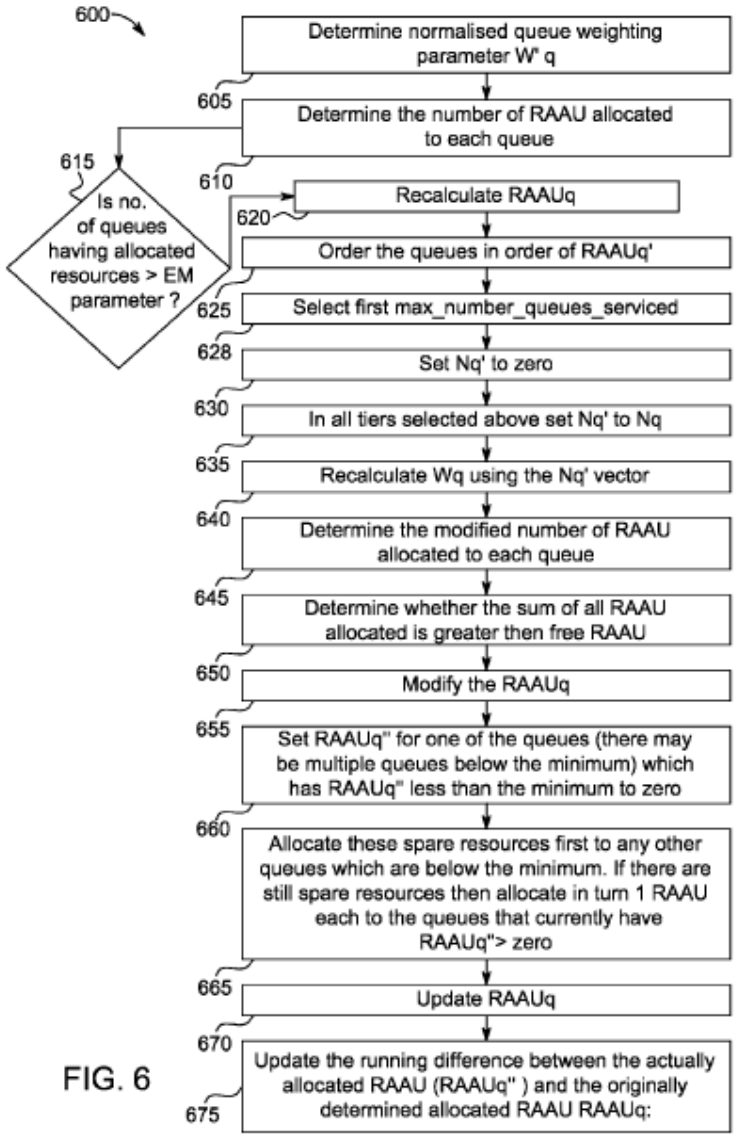


FIG. 6

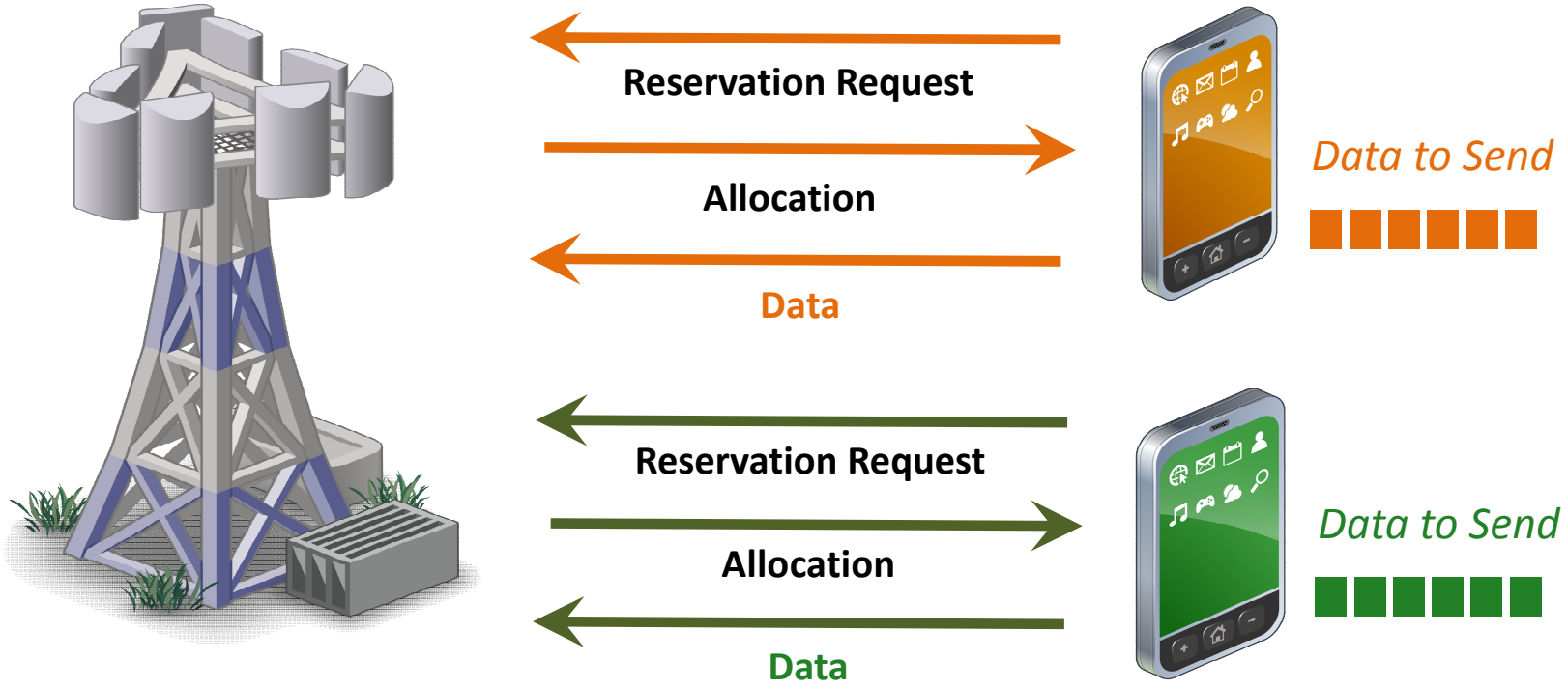
Figure 6 is an example of how a UE may divide its uplink allocation among radio bearers.

The base station need not transmit an allocation for each individual radio bearer, for every UE.

‘018 patent, Fig. 6, 4:14-26

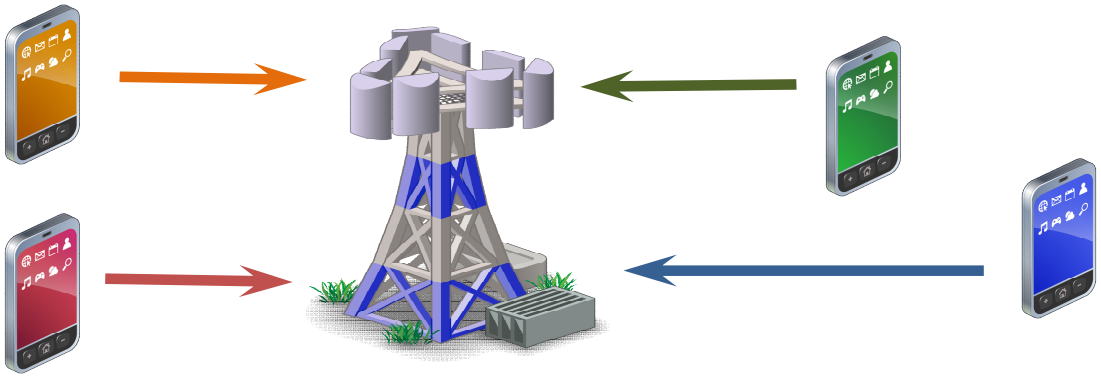
U.S. Patent No. 8,897,828

Overview of Uplink Scheduling



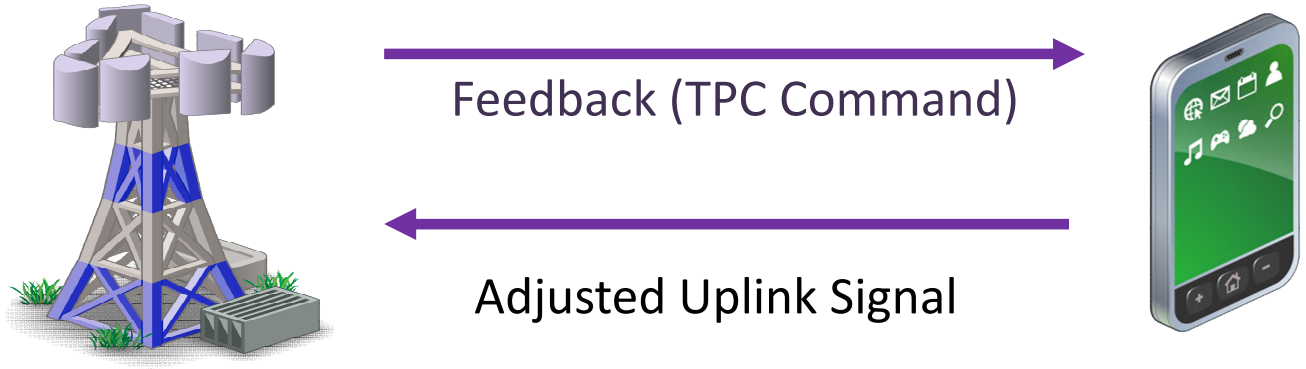
- A Phone with data packets to send to the network transmits a ***Reservation Request*** to the base station.
- The base station analyzes the request, and sends an ***Allocation*** of uplink channel resources.
- The phone uses the allocated resources to send ***Data***.

Control of Uplink Transmit Power Levels



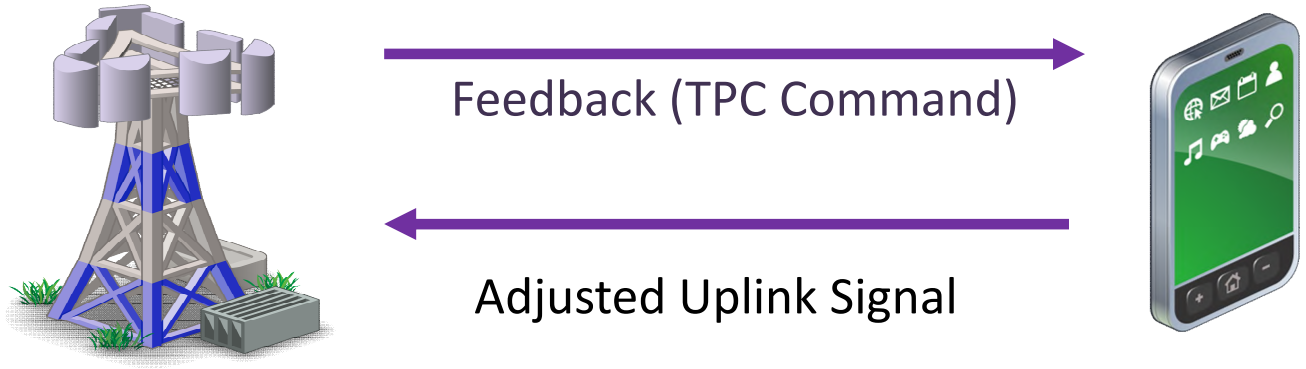
- Cell phone **Transmit Power Level** must be controlled:
  - Too low transmit power and the signal might be too weak to be detected.
  - Too high transmit power and the signal may interfere with other signals.
- Technical Challenges:
  - A cell phones is mobile; less transmit power is needed as it moves closer to a base station, but more transmit power is needed as it moves away.
  - Transmit power levels must be adjusted to compensate for other effects including weather and proximity to physical structures.

Closed Loop Power Control



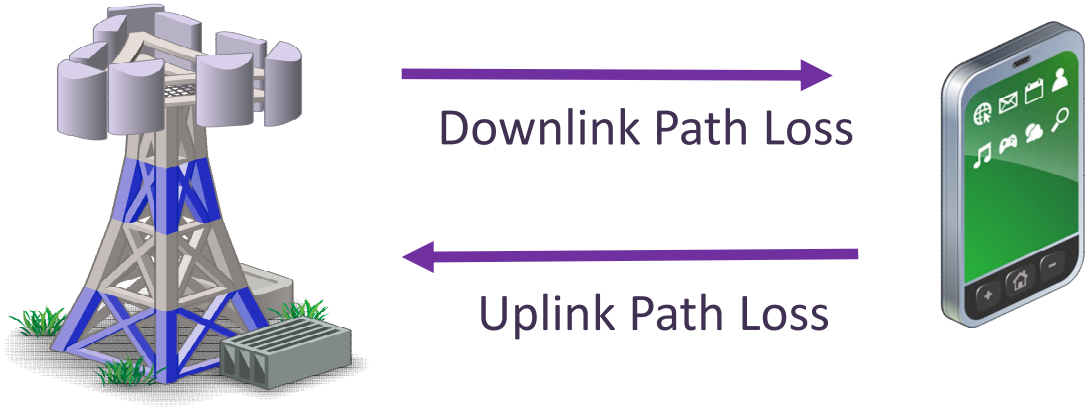
- Closed Loop Power Control is performed using **feedback**.
- **The Base Station**:
  - measures the strength of a signal received from a phone; and
  - sends a transmit power control (TPC) command instructing the phone to increase or decrease its power level by a specified value (*e.g.,* +1 or -1).

Closed Loop Power Control



- **Non-Accumulation Type**: the phone adjusts the transmit power by the value specified in the current TPC command, with no consideration of prior TPC commands.
- **Accumulation Type:** the phone accumulates the values sent by the current TPC command and previous TPC commands, and adjusts the transmit power by that accumulated amount.

Open Loop Power Control



- Open loop control is based on measurements of path loss.
- ***Downlink* path loss** is determined by a process in which:
  - the base station sends a reference signal with an indication of the power level at which it is sent; and
  - the phone receives the signal, measures its power level, and compares the measured power level to the sent power level to determine path loss.
- ***Uplink* path loss** is estimated to be the same as the downlink path loss. The phone adjusts its transmit power based on this estimation.

’828 Pat., 4:35-61, 5:66-6:5.

Combined Open Loop / Closed Loop Power Control

- The`828 patent combines open loop and closed loop power control schemes in which power is calculated in accordance with the following simplified equation. *Id*., 8:4-10:14.

Power = Constant Value + **Path Loss Adjustment Factor** + **TPC Adjustment Factor** + Other Adjustment Factors

- These **Path Loss** and **TPC** adjustment factors provide open and closed loop compensation respectively. *Id*. These factors change dynamically as a phone moves relative to a base station. *Id*.
- "Other Adjustment Factors" are captured in various dependent claims. *Id*., cls. 6, 7.

Combined Open Loop / Closed Loop Power Control

Power = Constant Value + **Path Loss Adjustment Factor** + **TPC Adjustment Factor** + Other Adjustment Factors

- The invention uses different modes in which the **TPC Adjustment Factor** is determined differently. '828 Pat., Abstract, 11:24-25.
- The base station sends a signal to the phone indicating whether or not "accumulation" is enabled. *Id.*, 9:63-10:14.
- The **TPC Adjustment Factor** is determined differently depending on whether or not "accumulation" is enabled.

Combined Open Loop / Closed Loop Power Control

Power = Constant Value + **Path Loss Adjustment Factor** + **TPC Adjustment Factor** + Other Adjustment Factors

If "accumulation" is enabled:

- the phone accumulates values sent by the current TPC command and past TPC commands, and sets the **TPC Adjustment Factor** to the accumulated sum.
- For example, if the accumulated value starts at zero, and two different TPC commands carrying values of +1 and +2 are received in successive time intervals, then the accumulated sum is +3,and the **TPC Adjustment Factor** is set to +3.

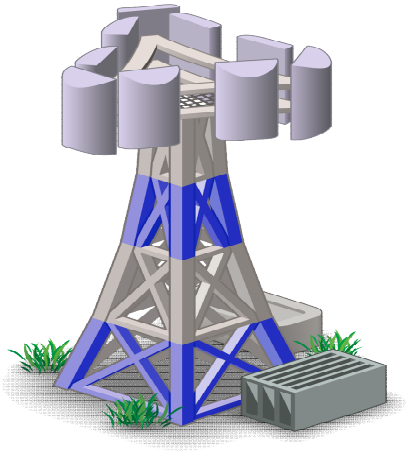
Combined Open Loop / Closed Loop Power Control

Power = Constant Value + **Path Loss Adjustment Factor** + **TPC Adjustment Factor** + Other Adjustment Factors

If "accumulation" is <u>not</u> enabled:

- The base station may or may not send TPC commands.
- If TPC commands are sent, the values of the TPC commands are *not* accumulated.
- For example, if two different TPC commands carrying values of +1 and +2 are received by a phone in successive time intervals, these values are not accumulated, but instead the **TPC Adjustment Factor** will be set to +1 in the first time interval, and then set to +2 in the later time interval.

Single Physical Channel Used for TPC Commands and Allocation



single physical channel

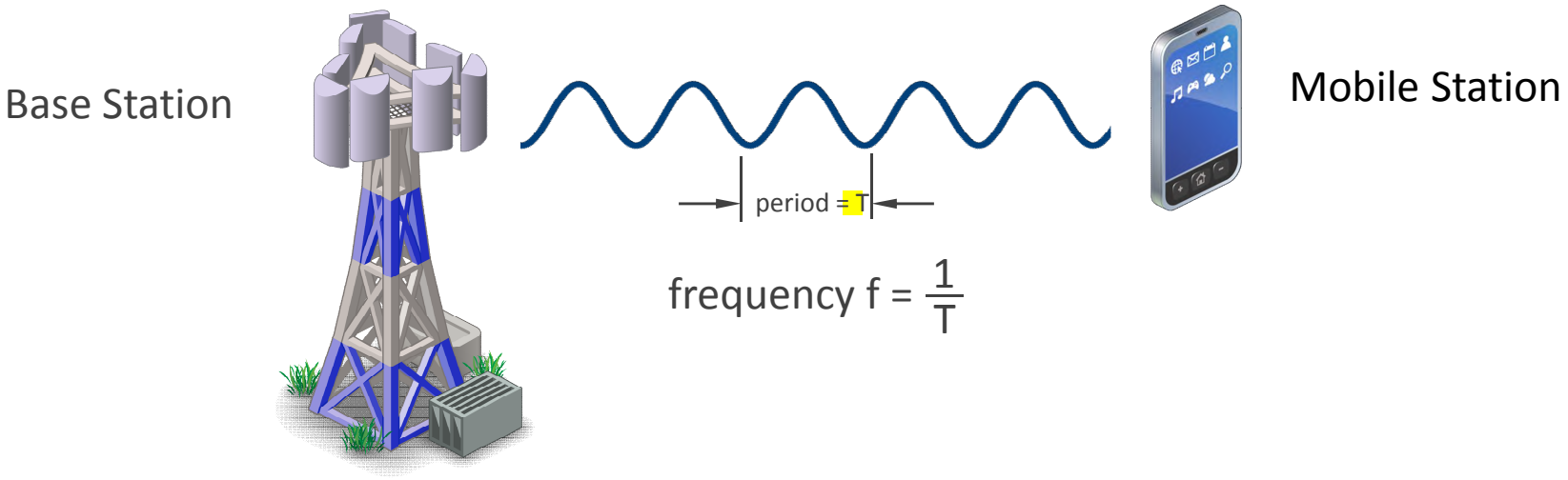
(1) Allocation of a Scheduled uplink resource.

(2) TPC Command

- The base station uses a single physical channel to send both
  - an allocation of a scheduled uplink resource; and
  - a TPC command.
- Using a single physical channel allows for a reduction in signaling overhead. ’828 patent at 12:39-54.

U.S. Patent No. 8,953,641

'641 Patent: Variable Channel Bandwidth Communication



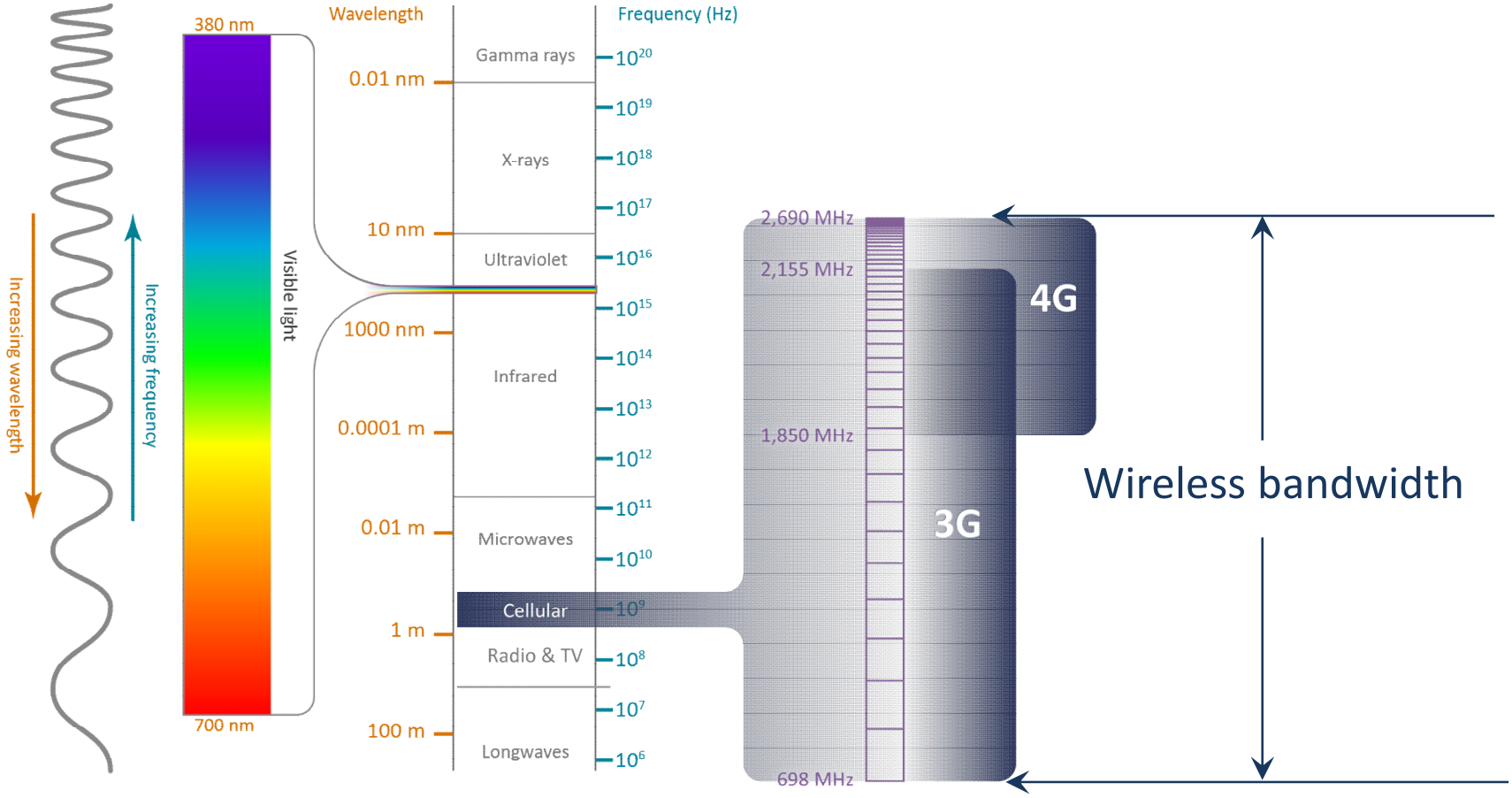
- Mobile stations send and receive signals and data to and from base stations ("BTS") by means of radio waves transmitted over the air.

- Radio waves are electromagnetic signals that propagate over the air at particular frequencies.

Frequency Spectrum and Bandwidth

- The frequency range, or frequency band, used by a base station to communicate between one or more mobile stations is referred to as an operating channel.
- The span (width) of a frequency band is called its "bandwidth."
- Similarly, the span of an operating channel is its channel bandwidth.

Frequency Spectrum and Bandwidth



- The FCC allocates wireless spectrum for wireless communications.
- Allocated wireless spectrum may be used to support one or more operating channels.

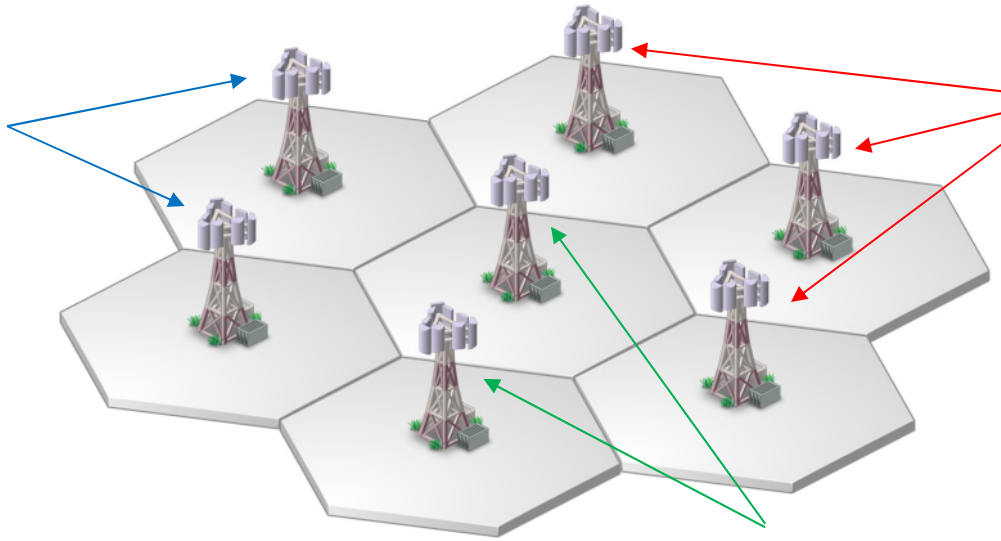
Frequency Spectrum and Bandwidth

- Wireless spectrum is a finite, valuable resource that network operators must use as efficiently as possible.
- Because wireless spectrum is so valuable, and fragmented, network operators use different operating channels and channel bandwidths within their networks.
- Channel bandwidths may be assigned from a set of available bandwidths to be used by BTSs to communicate with mobile stations. For example, a set of possible channel bandwidths could be 5, 6, 8, and 10MHz.

’641 patent, 1:31-2:3,
4:62-5:6 7:1-18 FIG. 10

Variable Channel Bandwidth Environment

BTSs using 8MHz channel bandwidths in the 2GHz operating channel



BTSs using 10MHz channel bandwidths in the 1GHz operating channel

BTSs using 6MHz channel bandwidths in the 1GHz operating channel

- As a result, a wireless network operator may assign different operating channels and channel bandwidths to different BTSs
- Each BTS operates at least one cell, each of which may transmit its own channel bandwidth.

’641 patent, 3:65-4:54, 7:1-18 FIG. 10

Variable Channel Bandwidth Environment

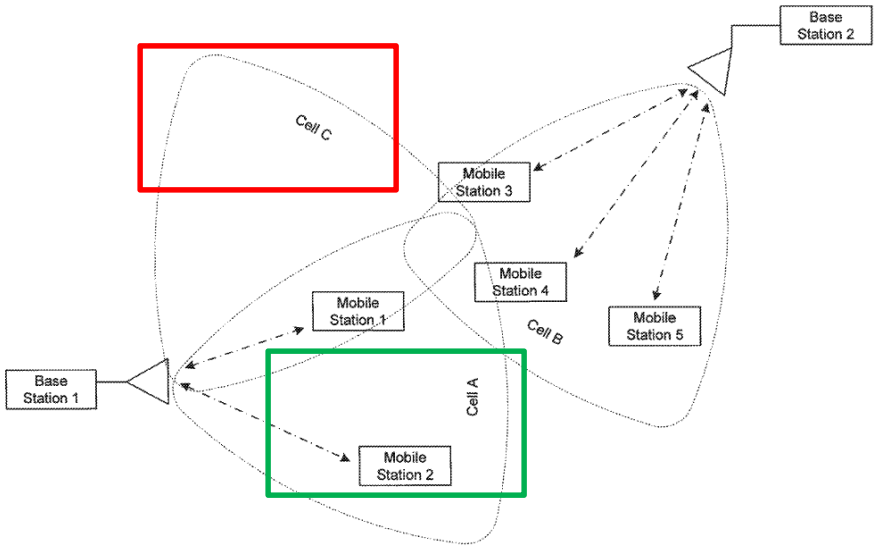


FIG. 10

- Thus, each one of multiple cells on a base station could also transmit using one of several different channel bandwidths available to the BTS system.
- For example, in the diagram above, BTS 1 could operate two cells: a 8MHz channel bandwidth in Cell A and a 6MHz channel bandwidth in Cell C .

'641 patent, 3:65-4:54 7:1-18 FIG. 10

Variable Channel Bandwidth Environment

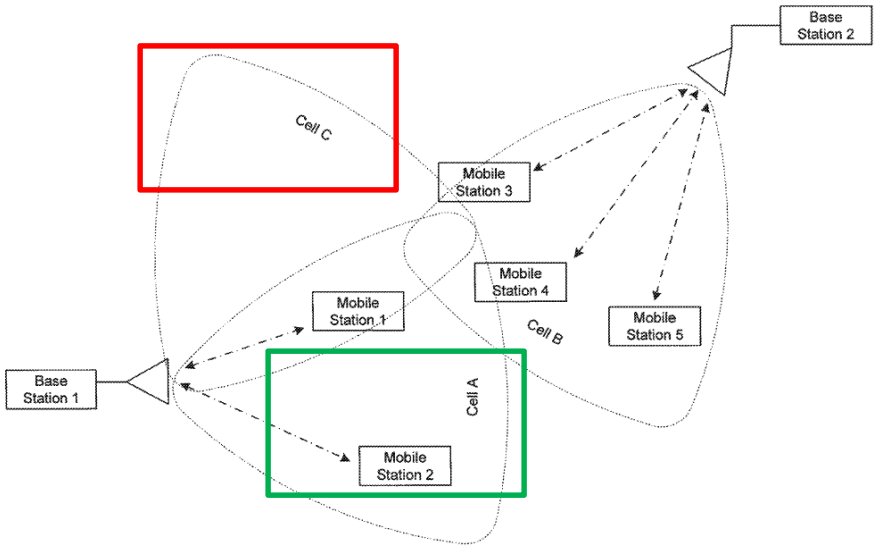


FIG. 10

- When a mobile station enters a new geographic area, and needs to connect to a new cell and/or BTS, it must first synchronize with that BTS and determine the operating channel bandwidth.
- Therefore, the BTS transmits synchronization signals and broadcast channels in a particular frequency segment.

’641 patent, 3:65-4:54, 4:63-6:30, 7:1-18, FIG. 10

'641 Patent: Variable Channel Bandwidth Communication

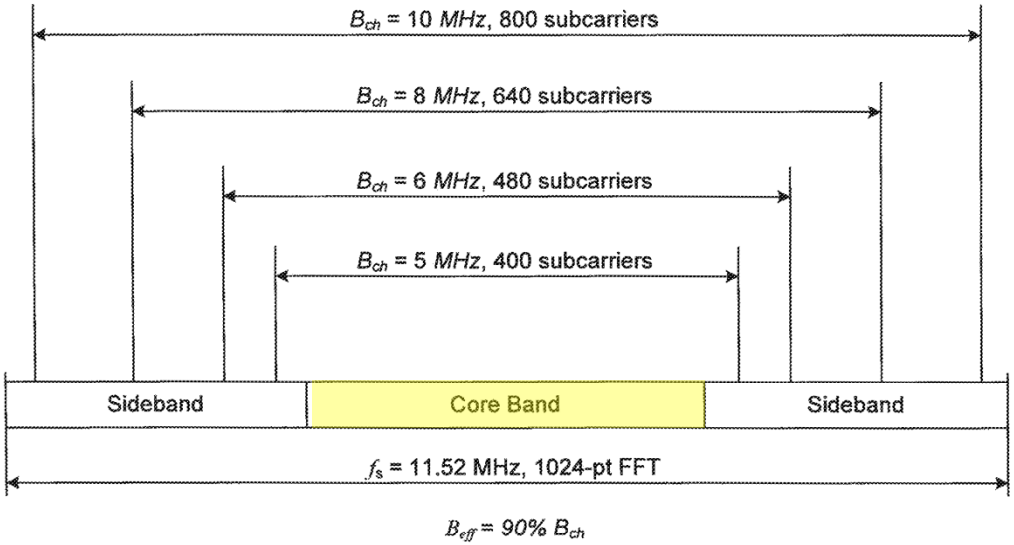


FIG. 6

- The mobile station receives the synchronization signals and broadcast channel by listening to that particular frequency segment, which is called the "core-band."

'641 patent, FIG. 6, 4:63-6:30

’641 Patent: Variable Channel Bandwidth Communication

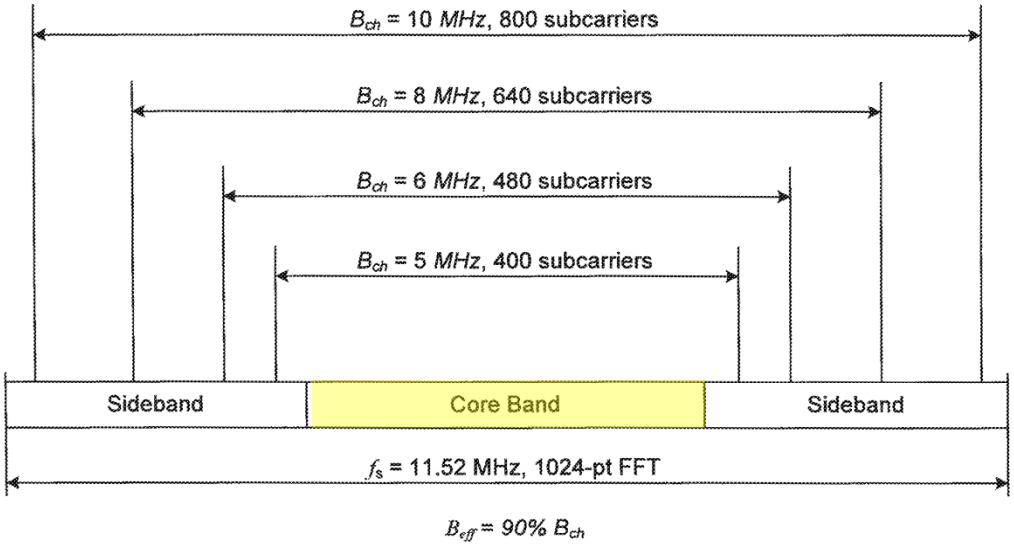


FIG. 6

- By receiving synchronization signals and broadcast channels located only in the core-band, the mobile station only needs to examine one part of the frequency band to find synchronization and bandwidth information- which reduces system complexity and increases efficiency.

’641 patent, FIG. 6, 1:57-2:3, 4:63-6:30

'641 Patent: Variable Channel Bandwidth Communication

Available operating channel bandwidths

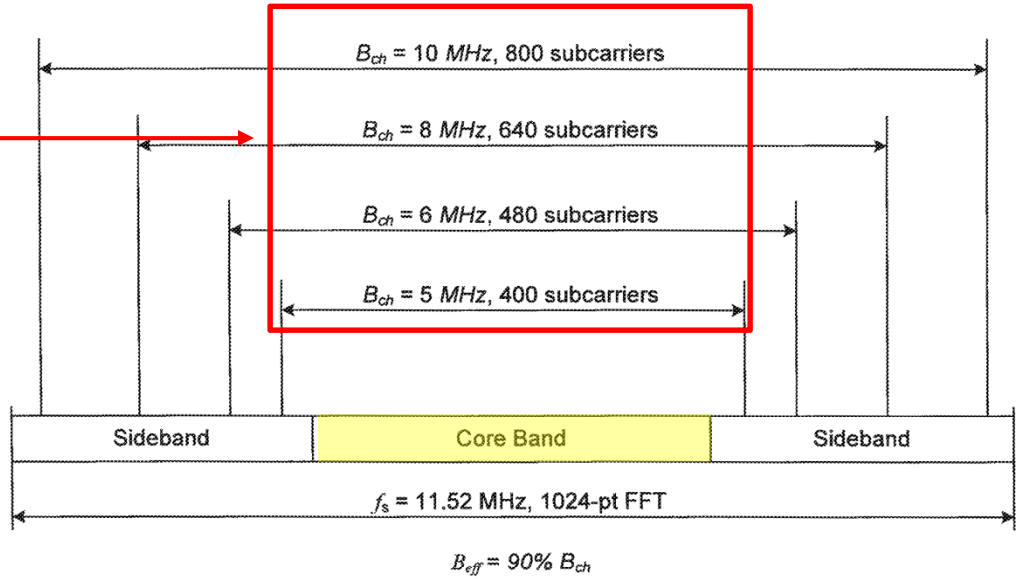


FIG. 6

- The core-band is a frequency segment not greater than the lowest of multiple available operating channel bandwidths.
- The core-band remains the same size frequency segment regardless of the operating channel bandwidth's size.

'641 patent, FIG. 6, 4:63-6:30

'641 Patent: Variable Channel Bandwidth Communication

Available operating channel bandwidths

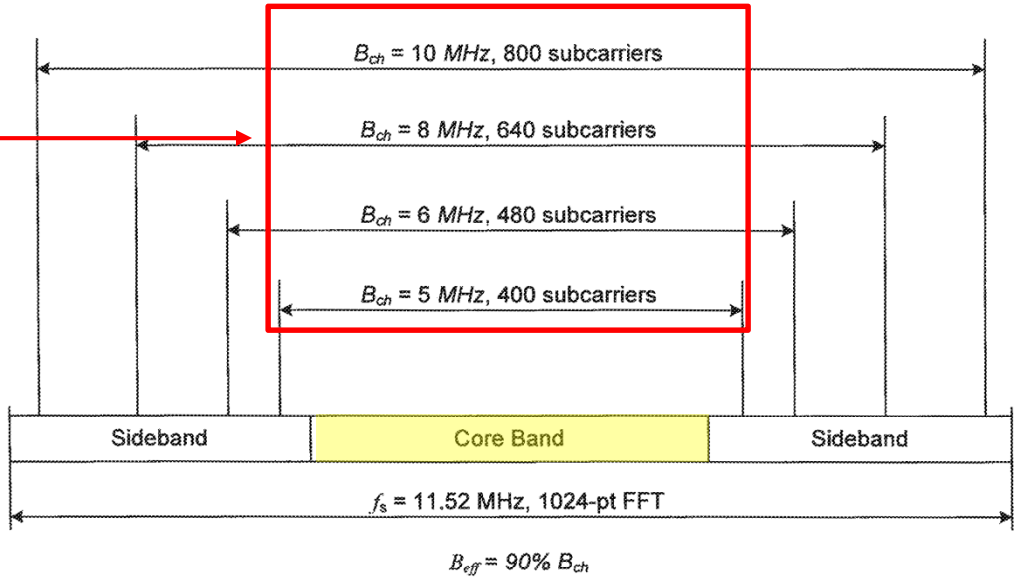


FIG. 6

- The "core-band" contains synchronization signals and broadcast channels – which may include information identifying the operating channel bandwidth being used by the BTS.

'641 patent, FIG. 6, 4:63-6:30

’641 Patent: Variable Channel Bandwidth Communication

Available operating channel bandwidths

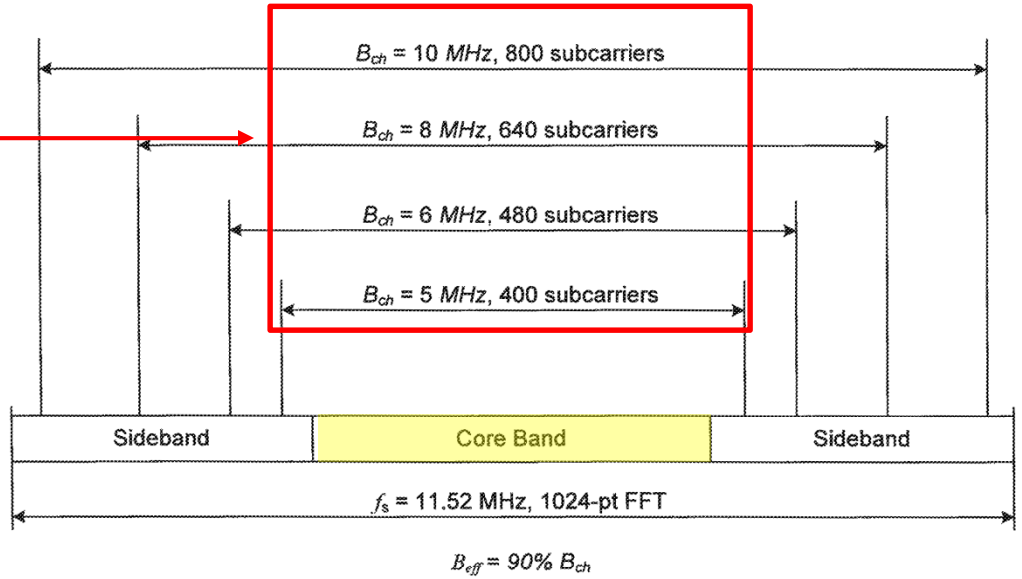


FIG. 6

- No matter which of the possible operating channel bandwidths the BTS is using, the mobile station can locate synchronization signals and operating channel bandwidth information by receiving signals located only in the core band.

’641 patent, FIG. 6, 4:63-6:30

’641 Patent: Variable Channel Bandwidth Communication

Available operating channel bandwidths

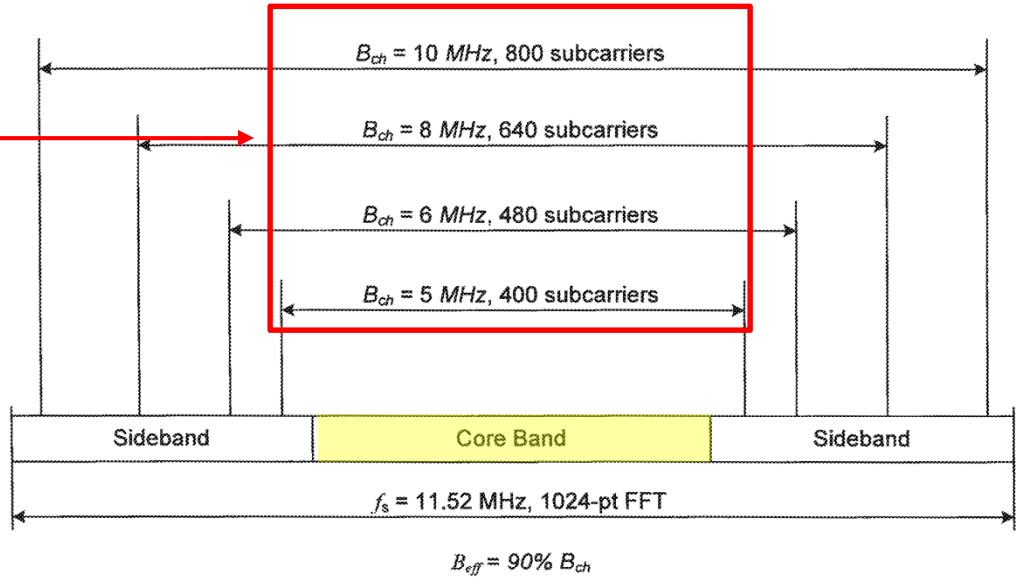


FIG. 6

- Upon receiving the synchronization signals and operating channel bandwidth information from the core-band, the mobile station can then determine which of the operating channel bandwidths the BTS is using.

’641 patent, FIG. 6, 4:63-6:30

'641 Patent: Variable Channel Bandwidth Communication

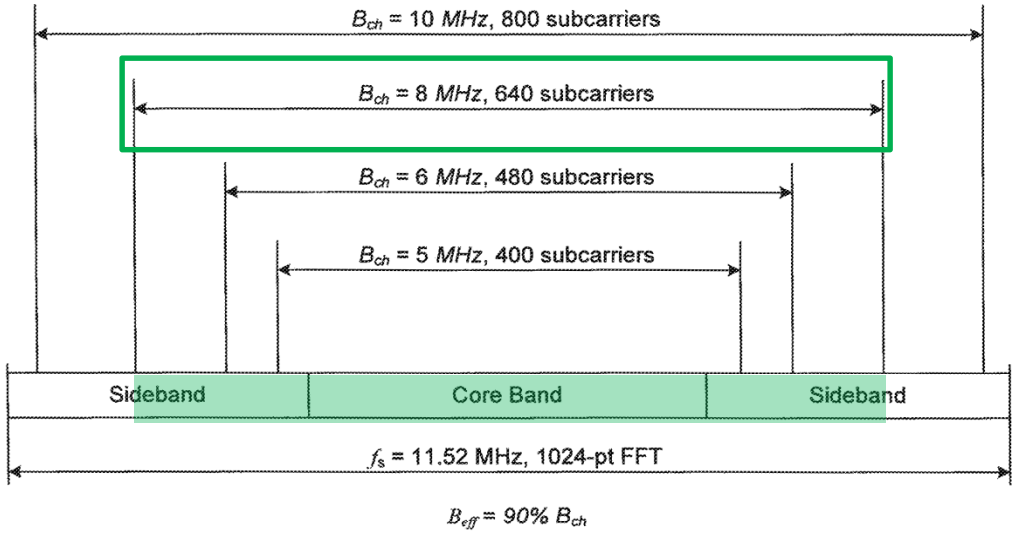


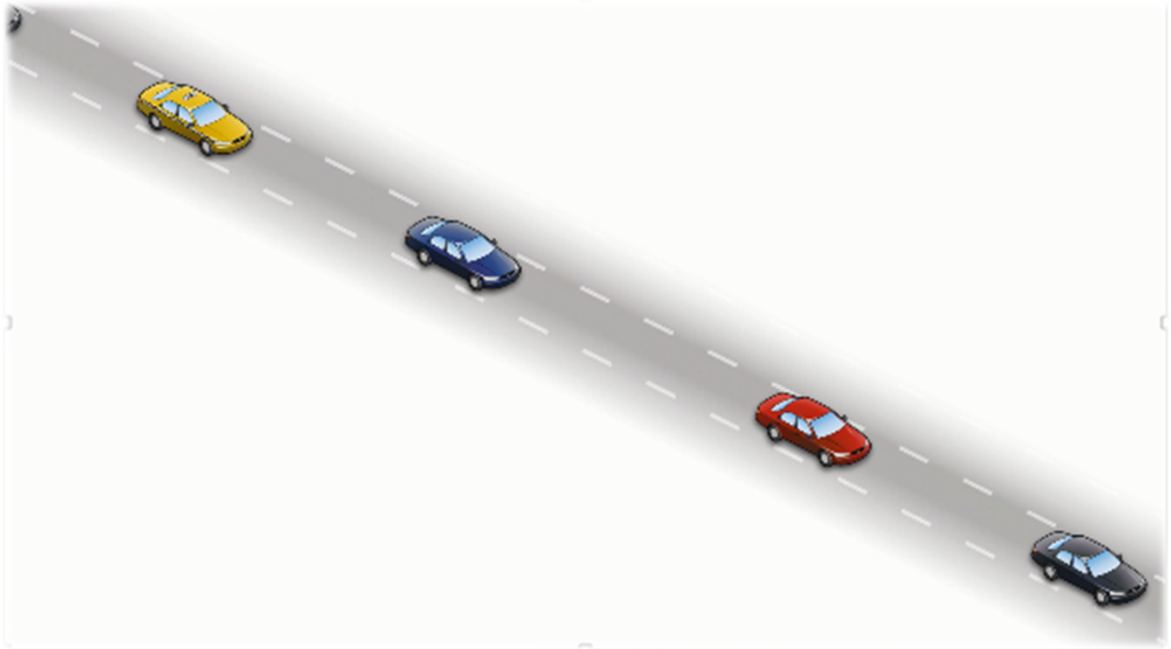
FIG. 6

- Once the operating channel bandwidth being used by the BTS is determined, the mobile station begins using that bandwidth.
- For example, the mobile station determines the BTS is operating a 8MHz channel bandwidth (out of an available 5, 6, 8, and 10 MHz), and then begins using this bandwidth.

'641 patent, Abstract, FIG. 6, 4:63-6:30

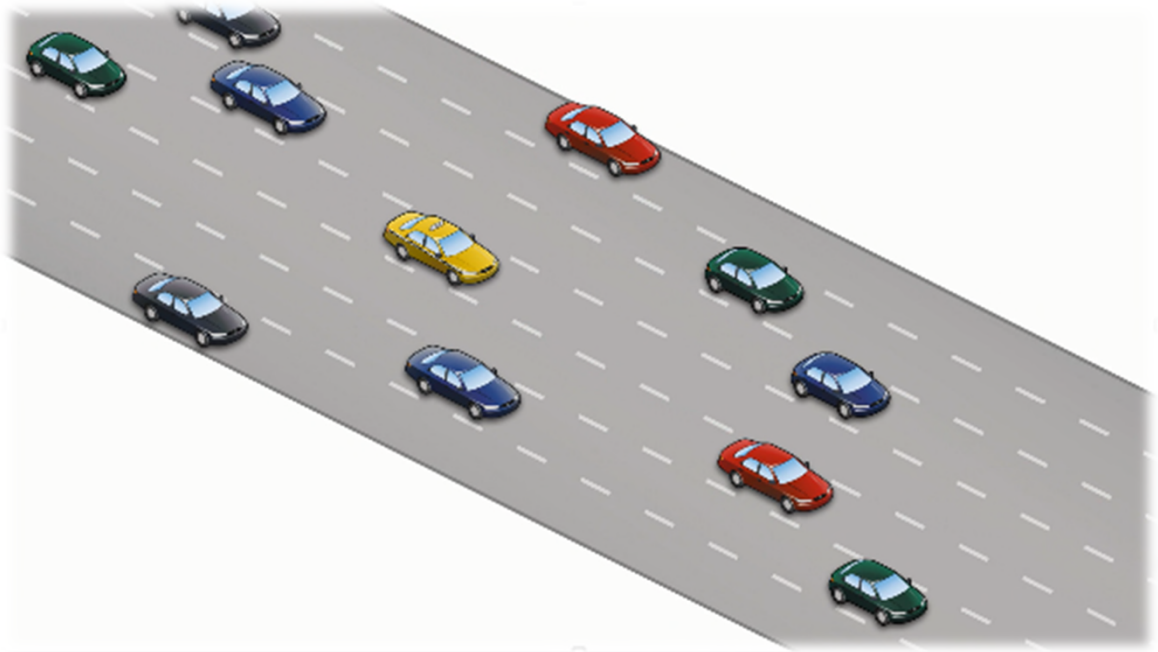
'641 Patent: Variable Channel Bandwidth Communication

- The `641 Patent invention is like a multi-lane road, where the cars initially don't know how many lanes are available for use.
- As a result, they're confined to the middle lane looking for instructions located in that lane stating what lanes are available.



’641 Patent: Variable Channel Bandwidth Communication

- Then the cars see traffic signs in that lane indicating all seven lanes are open, so the cars spread out and more traffic can flow.



’641 Patent: Variable Channel Bandwidth Communication

- Likewise, mobile stations “listen” on a particular portion of the available bandwidths, the core-band, for synchronization signals and broadcast channels that will allow them set up full bandwidth operation.
- Upon setting up full bandwidth operation, mobile stations can then use the particular channel bandwidth of the BTS.